A Foundation for Coalition Interoperability Using NATO's C3 Technical Architecture

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Current projections indicate that in the future, the ability to share information between military systems will ultimately determine whether or not a mission will be a successful. Based on the probability that conflicts will continue to occur involving allied command structures that utilize diverse information systems, information interoperability will be the crucial factor for success when conducting future combined and joint military operations. This paper describes an architectural approach that lays the structural foundation necessary to attain interoperability between diverse C3 systems and provides the rationale on why this approach has been proposed for use throughout NATO.

The North Atlantic Treaty Organization (NATO) has recognized that future military information systems will need to interoperate with one another more effectively than ever before[1]. The number of unforeseen contingencies and international conflicts have elevated the need to provide accurate information to the warfighter upon demand, i.e., wherever and whenever it is needed.

However in order to make this a reality, it is obvious that future coalition information system services will need to be fused together, having the ability to retain their own national identities and operational independence, as well as interoperate with one another in a more effective and seamless manner.

Unfortunately, achieving and sustaining interoperability among diverse systems is not, nor has it ever been an easily attainable objective. As indicated in [1], historically speaking, interoperability has been one of the most difficult areas with which to deal. Interoperability is a broad and complex area of endeavor that cuts across many functional domain areas and applications. Often deemed elusive due to the level of complexity entailed when integrating diverse system components together, the real challenge lies in the overall scope and extent of the system, as well as the level of interoperability and integration desired [2].

Nevertheless, integrating diverse military system components together cohesively within a coalition environment can add significantly to the level of complexity entailed. For instance, when different parts of a system are built separately by independent developers, the end results often vary greatly. This may be attributed to flaws in the design specification and/or how it has been interpreted during various system development stages.

The term used synonymously with design specification today is architectural design. The architectural design is concerned with determining the architectural style of the system as opposed to the detailed design of individual algorithms and data stores. Architectural design also involves the high-level decomposition of the system into components and the relationships and interactions of these components, which usually determines the specific architecture of the system [3]. If misinterpreted or designed poorly, chances are the system(s) once fielded will function improperly, or more than likely, in a limited capacity.

When put in the context of a coalition environment, the ratio for failure increases significantly due to the sheer number of diverse factors that must be taken into account and reckoned with accordingly (e.g., language differences, level of training, number of system developers and integrators involved, type of experience, etc.).

Architectural Views and Interoperability

In 1996, the U.S. Department of Defense (DoD) first introduced the concept of architectural views under the guise of a C4ISR Architecture Framework[2]. Known independently as the Operational, System, and Technical Architectural Views, all three views, when logically combined together, expanded on the de facto definition pertaining to architecture within the realm of information technology[3]. Until that time, there had been no common approach for architectural development throughout the DoD.

As a combined effort, NATO in turn refined each one of these architectural views and incorporated them into what is now known as the NATO Policy for C3[4] Interoperability. All three views as defined below, are considered critical elements of the NATO C3 Interoperability Environment (NIE):

- Operational View: This view describes the tasks and activities, organizational and operational elements, and information flows required to accomplish or to support military or consultation function.
- System View: This view is generated from the Operational View by the responsible host nation or design authority. It describes and identifies the system(s), both internal and external, and interconnections required to accomplish or to support the military or consultation function. This view maps information flows, hardware, and applications to user locations and specifies the connectivity, performance, and other constraints.
- Technical View: This view, generated by the host nation or equivalent authority, describes the arrangement, interaction, and interdependence of the elements of the system and takes into account the technical constraints imposed by the Systems View. It provides the minimal set of rules governing the selection of the appropriate standards and products from the implementation domain.

The NIE encompasses the standards, products, and agreements adopted by the Alliance to ensure C3 interoperability. It serves as the basis for the development and evolution of C3 Systems.

Organizational Structure

NATO has defined interoperability organizationally as the ability of systems, units, or forces to provide services to, and accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively [4].

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The primary organization within NATO that addresses interoperability policy and procedures is the NATO Consultation, Command, and Control Board (NC3B). Structurally, the NC3B consists of eight sub-committees, two of which play an important role in the context of this paper. The first, the Interoperability Sub-Committee is responsible for establishing C3 systems interoperability policy and implementing C3 standardization objectives deemed necessary for improving interoperability. Underneath the Interoperability Sub-Committee are four working groups. Each in their own right helps to perpetuate interoperability policy and standardization initiatives throughout the alliance.

The second, known as the Information Systems Sub-Committee (ISSC) is, at the moment, comprised of eight working groups that primarily address and support information system implementation throughout all of NATO.

When examining NATO's overall interoperability structure collectively, we see that NATO has an interoperability framework (NIF) that can be divided into three distinct categories (see Figure 1):

1. Policy: The NATO Policy for C3 interoperability represents the policy layer. It is a policy that addresses all overarching and essential C3 interoperability issues, identifies each of the respective authorities and associated responsibilities, links existing interoperability documents, defines the relationship with the NATO Standardization Organization, and other relevant organizations.
2. Execution: The NATO Interoperability Management Plan and the five year Rolling Interoperability Program comprise this layer.
3. Products: The NIE comprises this layer [5].

In 1997, the NC3B identified several goals and objectives that were considered necessary to attain interoperability between NATO common funded C3 systems. In response to these goals and objectives, the NC3B ISSC formed the NATO Open Systems Working Group (NOSWG), tasking them to develop a technical architecture on behalf of NATO. The technical architecture would become known as the NATO C3 Technical Architecture (NC3TA) [6].

Upon completion, the NC3TA would provide the structural foundation necessary to attain information interoperability between NATO C3 systems and national systems, as well as address interoperability concerns for all NATO common funded systems. Furthermore, the NC3TA would perpetuate the development of a common core for the Bi-SC[5] Automated Information System (AIS).

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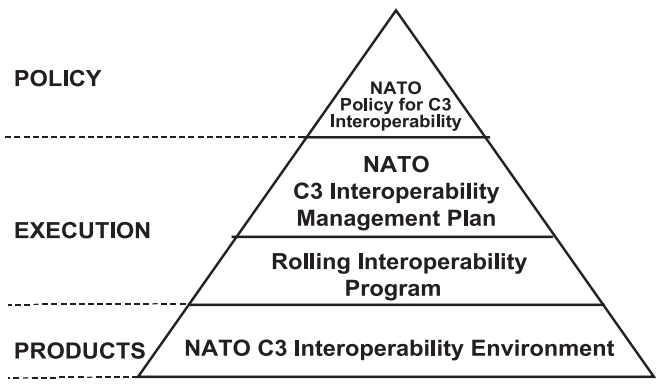
NATO C3 Technical Architecture

To facilitate the creation of the NC3TA, the NOSWG first assessed the merits of each national architectural effort early on, gleaning from each as much as practically possible. Each had technical merit but differed in overall content and composition. As a result, the NOSWG decided to develop the NC3TA in accordance with the definition for a technical architectural view[6] as much as feasibly possible. By definition, this meant that it would provide the minimal set of rules governing the selection of appropriate standards and products from the implementation domain. Moreover, the NC3TA would also extrapolate, as well as improve upon existing approaches from each one of the contributing national technical architectural efforts.

A look at the overall structure and content shows that in contrast to national technical architectural efforts, the NC3TA is unique in that it is comprised of a five-volume set that consists of the following[7]:

- Volume 1–Management: This volume provides the management framework for the development, as well as the configuration control of the NC3TA. It includes the general management procedures for the application of the NC3TA in NATO C3 systems development.
- Volume 2–Architectural Models and Description: This volume principally supports a NATO technical framework to provide a common basis for the establishment of the architecture for NATO information system projects. It also offers a vision on the use of emerging off-the-shelf technologies.
- Volume 3–Base Standards and Profiles: This volume contains all of the current open system and communication standards applicable to NATO information systems, as well as guidance for their use.
- Volume 4–NATO C3 Common Standards Profile (NCSP): This volume mandates the subset of standards that are critical to interoperability. It provides the link between degrees of interoperability as described in the NATO policy for interoperability of C3 systems, and standards selection.
- Volume 5–NATO C3 Common Operating Environment (NCOE): This

Figure 1: *NATO's Interoperability Framework*



volume is the NCSP standards-based computing and communication infrastructure.

The chairman of the NOSWG meets regularly with other NC3B working groups to ensure that all areas of technical concern (e.g., security, data, communications, etc.) are taken into account by the appropriate working group bodies [7]. This simple cross evaluation and coordination procedure serves as only one of the preliminary fail-safe steps that is required as a part of the overall NC3TA management process described in Volume 1.

Consistently updated, Volume 2 reflects various architectural models such as the Technical Reference Model, the NATO Component Model, as well as definitive descriptions or reference pointers to new and emerging technologies such as JAVA and the eXtensible Markup Language. The descriptions provided are primarily derived from the NATO Open Systems Environment and NATO Open Systems Interconnectivity Profile that essentially serve as reference material to the system developer, implementor, and end-user. Editorial updates are made primarily through the NC3 Agency.

The encyclopedic nature of Volume 3 serves as another reference document. It too is derived from the NATO Open Systems Environment and NATO Open Systems Interconnectivity Profile and contains all of the current references on communication and information standards. This volume will also be maintained in an HTML version on the web[8].

Due to their impact on the systems design, development, and implementation for all NATO common funded systems, the two remaining Volumes 4 and 5 of the NC3TA are considered extremely important (see Figure 2).

Volume 4, although considered to be quite mature, will undergo periodic updates in order to ensure that the evolution in standards are incorporated to benefit the developer/end-user community on a regular basis. The definitive process for submitting and incorporating candidate standards for consideration into the NCSP is outlined through the "change proposal" section of Volume 1. Volume 4 also has focused on attaining degrees of interoperability through an interoperability profiling procedure that is being worked in coordination with other affiliated sub-committee working groups.

In conjunction with Volume 4, Volume 5 is probably the single most important document within the NC3TA. To note its relevance, all NATO authorities are required, and the nations are encouraged to implement C3 Systems using the mandatory standards and products as specified in the NCSP and NCOE, in accordance with the NATO Policy for C3 Interoperability [8].

Once the NC3B approves future versions of the NCOE, those products that are identified for incorporation will be mandated for all NATO Common Funded Systems.

NCOE Significant Features

Volume 5 of the NC3TA is considered evolutionary and therefore a living document. While it will eventually specify particular products for incorporation into the NCOE, at the present time it does not. However once selected, these products will be primarily chosen from an off-the-shelf -based basket of products. These products will eventually populate the various service layers of the NATO Component Model, which capitalizes on the top-down layered approach provided by the Technical Reference Model as described in Volume 2 of the NC3TA.

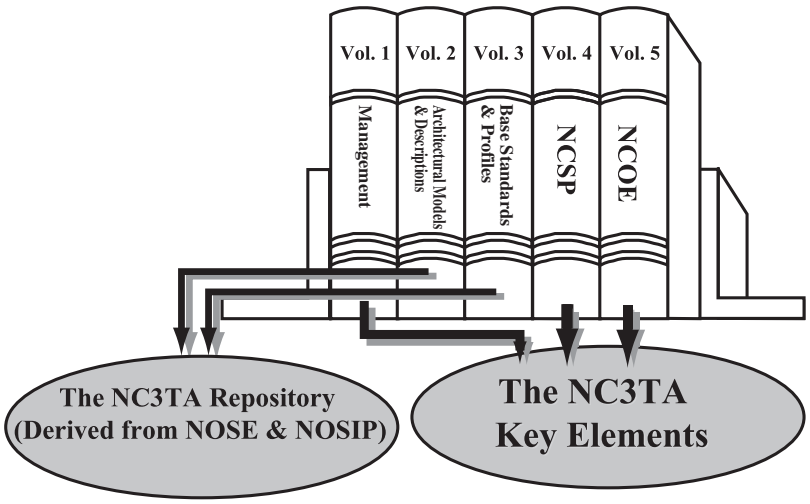
Following are the principle components of the NATO Component Model:

- Network Services: These constitute the basic transparent interfaces between the platform and the underlying networking infrastructure, including the IP layer services.
- Kernel Services: These are that subset of the NCOE component segments that are required for all workstations and servers (see Figure 3). At a minimum, this sub-set would consist of the operating system, windowing software, security services, segment installation software, and an executive manager.
- Infrastructure Services: These services directly support the flow of information across NATO systems. Infrastructure services provide a set of integrated capabilities that the applications will access to evoke NCOE services.
- Common Support Application Services: These services are necessary to view data in a common way (share data) across the network. They essentially promote inter-

Coalition Interoperability Acronym Guide

C3	Consultation, Command and Control.
C4ISR	Command, Control, Computers, Intelligence, Surveillance, and Reconnaissance.
ISSC	International Social Sciences Council
NATO	North Atlantic Treaty Organization.
NIE	NATO C3 Interoperability Environment.
NC3B	NATO Consultation, Command and Control Board.
NIF	NATO Interoperability Framework.
NOSWG	NATO Open Systems Working Group.
NC3TA	NATO C3 Technical Architecture.
AIS	Automated Information System.
NCSP	NATO C3 Common Standards Profile.
NCOE	NATO C3 Common Operation Environment.

Figure 2: *Relative Structure of the NC3TA*



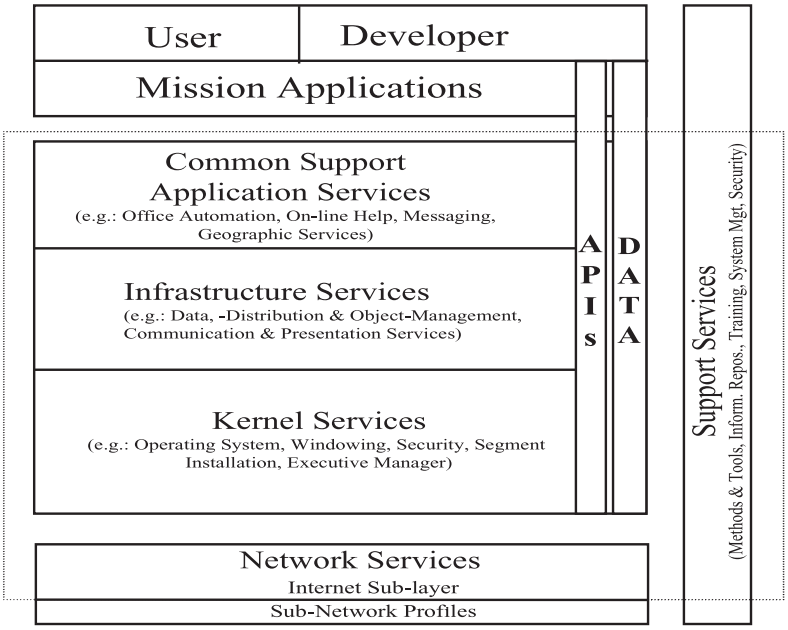


Figure 3: *NCOE Component Model*

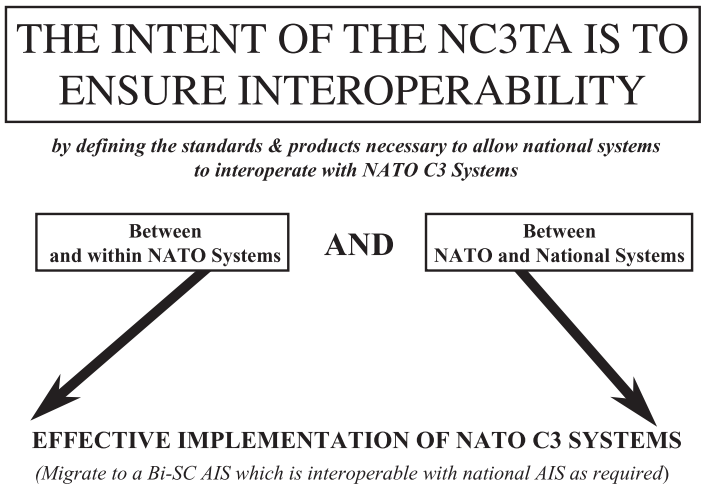
operability among various mission applications.

- Application Programming Interfaces: These are integrated into the NCOE through a common set of application programming interfaces, which are invoked by the applications and services as required.
- Data Component Definition: This refers to the way in which data is taken into account in the NCOE and is related to the main components of the NCOE (common support application services, infrastructure services, kernel service) and even, out of NCOE components *stricto sensu*, to mission applications.
- Support Services: These include methods and tools, information repository, training services, system management, and security.

Segmentation is one of the most debated and often discussed features of the NCOE. Segmentation can be defined in terms of the functionality that is seen from the end-user's perspective. It allows the user(s) to easily add only those required modules that are deemed necessary by the end-user community. This way, the end user may view the NCOE as a set of building blocks in which a system is built. Since the NCOE is not a system in and by itself, it can be more easily understood as the foundation for building open systems through such inherent features as segmentation. The overall concept for segmentation is predicated on national[9] as well as commercially viable efforts.

As noted previously, one of the goals and objectives of the NC3TA is the development of a common core. In direct response to this need, the Bi-SC AIS core will eventually be implemented utilizing those standards and products stipulated by the NCSP and NCOE. However, to do so will require that the basket of products be populated in the NCOE. The initial version of the NCOE was released in July of 1999 as Volume 5 of the NC3TA. The latest NC3TA version 2.0 was approved in May 2001 by the NC3 board. Version 2.0 provides an outline of the basket of products, as well as the set of interoperability standards profiles to be used by the Bi-SCs.

Figure 4: *Interoperability and the NC3TA*



Conclusion

Interoperability has long been an elusive and sought after goal. Especially, within the realm of coalition information systems. However, a well defined architectural approach can lay the structural foundation necessary to attain interoperability for diverse military information systems in the future (see Figure 4).

When all five volumes of the NC3TA are finalized, it is anticipated that the structural foundation will be in place for future coalition systems to build systems upon for years to come.◆

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Notes

1. Item 4 of the Defense Capabilities Initiative issued during the Washington Summit on April 23-24, 1999.
2. C4ISR Architecture Framework, Version 1.0.
3. IEEE Std 610.12 lists complete definition.
4. Within NATO, C3 refers to "Consul - tation, Command, and Control."
5. The two Major NATO Commands, i.e., Supreme Headquarters Allied Powers Europe (SHAPE) and Supreme Allied Commander Atlantic (SACL-ANT).
6. For more details, see the NATO C3 Interoperability Environment (NIE).
7. For a complete description, see NC3TA Vol. 1.
8. The NC3TA is accessible at http://194.7.79.15
9. For more details see DII COE at www.disa.mil

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